

SELECTION OF CHANNELS AND FEATURES FOR EEG-BASED USER IDENTIFICATION USING OPTIMIZATION ALGORITHMS

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ABSTRACT

In recent years, the Brain-Computer Interface (BCI) technology with Machine Learning (ML) has opened new avenues for user identification. Electroencephalography (EEG) -based method offers a unique advantage by utilizing the brain's electrical activity, which is difficult to replicate or forge. However, the inherently low amplitude and high dimensionality in EEG signals pose significant challenges for user identification. Thus, selecting relevant channels and features is critical for reducing computational complexity and improving efficiency of the identification system. Therefore, this study focuses on optimizing EEG channels and features derived from the EEG signals using ML approaches. Rapid Serial Visual Presentation (RSVP) was used in this study as task paradigm where visual stimuli were rapidly presented to evoke P300 signals. From the pre-processed signals, 165 features were extracted using Time Series Feature Extraction Library (TSFEL). Further, optimization techniques were employed to identify the most informative subsets of channels and features suitable for user identification. The effectiveness of these subsets was evaluated using ML classifier with random search and 5-fold cross-validation, to prevent overfitting. The top-performing channels and features identified by Sequential Forward Optimization and Genetic Algorithm were combined for further optimization. As a result, six-channels such as O2, PO3, P3, FC2, CP1, and CP2 were selected, along with five features. The optimized configuration achieved classification accuracy, precision, recall and F1-score of 97.21%, 97.95%, 97.21% and 97.14%, respectively. Notably, the selected channels correspond to brain regions associated with RSVP, demonstrating their relevance to the task.

Keywords: EEG, RSVP, TSFEL, Optimization Techniques, Machine Learning, User Identification

INTRODUCTION

User identification based on EEG refers to the process of recognizing or verifying an individual's identity through the analysis of their brain activity patterns [1]. Brain signals can vary significantly between individuals due to unique neural pathways and cognitive processes [2]. Many traditional biometric systems can be spoofed using fake fingerprints, photographs, or masks, which raises security concerns [3]. In contrast, EEG-based identification offers advantages such as high uniqueness, difficulty to replicate, and robustness against environmental factors, making it a promising alternative to traditional biometric methods [4].

Task paradigms are essential in EEG-based user identification as they evoke distinct brain activity patterns unique to individuals [5]. It involves a structured set of tasks or activities, often accompanied by stimuli, to systematically analyze brain signals [6]. Previous studies in the literature have demonstrated that classification performance remains consistent regardless of the specific task paradigm used [7]. Commonly utilized paradigms include eyes open, eyes closed, motor movements, auditory, mental,